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EVALUATION OF ECONOMIC BENEFITS FOR FLOOD CONTROL AND WATER RESOURCE PLANNING

General Principles and Standards of Benefit Evaluation

Title 33—Navigation and Navigable Waters

CHAPTER II—CORPS OF ENGINEERS, DEPARTMENT OF THE ARMY

PART 341—EVALUATION OF ECONOMIC BENEFITS FOR FLOOD CONTROL AND WATER RESOURCE PLANNING

General Principles and Standards of Benefit Evaluation

Notice is hereby given that the regulation set forth below by the Secretary of the Army (acting through the Chief of Engineers) prescribes revised implementing policy and procedures pursuant to section 1 of the Flood Control Act of 22 June 1936 (Pub. L. 74–738). Specifically, the regulation emphasizes the procedures and measurement techniques for evaluating benefits under the national economic development objective for flood control and related water resources planning.

Since this regulation prescribes a general policy statement and specific evaluation procedures and measurement techniques designed primarily for internal use by Corps professional staff, notice of proposed rulemaking and the procedures thereto is considered unnecessary. This regulation will become effective August 15, 1974. It does not apply to planning reports submitted to the Office of the Chief of Engineers (OCE) prior to the effective date. It applies fully to all planning reports submitted to OCE after December 31, 1974. It will be applied partially to planning reports submitted between August 15, 1974 and December 31, 1974.

Dated: 5 August 1974.

JAMES L. KELLY,
Brigadier General, USA,
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Sec.

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AUTHORITY: Flood Control Act of 1936, Pub. L. 74–738 (33 U.S.C. 701a), June 22, 1936; Water Resources Council, Principles and Standards for Planning Water and Related Land Resources, 38 FR 24778–24869, September 10, 1973.

Subpart A—Introduction

§ 341.10 Purpose.

This regulation outlines the principles, standards, procedures and measurement techniques for evaluating benefits under the national economic development objective for flood control and related water resources planning. This is one of the objectives contained in the Principles and Standards of 10 September 1973.

§ 341.11 Authority.

(a) Flood Control Act of 1936, Pub. L. 74–738, 33 USC 701a, June 22, 1936;

(b) Water Resources Council, *Principles and Standards for Planning Water and Related Land Resources*, 38 FR 24778–24869, September 10, 1973.

§ 341.12 Definitions.

"Activity." Any firm, household or public service entity, be it governmentally sponsored, private, profit making, quasi-public, charitable, etc.; sometimes used in text to mean all activities of a similar type; e.g. (residential, agricultural, manufacturing, or commercial).

"Activity decisions." A choice by an activity based upon maximization of its net income (economic rationality, net income).

"Alternative site, available alternative, alternative location." (a) Broadly, any location where a given activity might locate outside of the flood plain; (b) specifically, the best available non-flood plain location at a given point in time, as measured by maximization of net income to the activity. As a rule the site is not available if it is already occupied by a similar activity type or it will be occupied by a similar activity type both with and without the project. If an already occupied site is to be considered as the alternative, the costs of moving, including any unrecovered sunk costs, lost interest and profits during moving and any diseconomies to employees must be fully accounted for. As a practical matter, these costs will usually preclude use of occupied sites unless the useful life of the structures is near zero.

"Area affected." The area affected by a proposed plan is the flood plain plus other areas likely to serve as alternate sites for activities which might use the flood plain if it were protected.

"Associated costs." The cost necessary to make one site equally valuable as another. Value is measured either as gross income (revenues) or as other total output for non-monetary activities, such as schools (value, activity, development costs, site development costs, site operating costs, locational advantages).

"Average annual flood damages." See "Flood damages."

"Base year." The first year in which the plan is expected to become operational.

"Benefit." An NED benefit means an increase in the Nations' output of goods and services and/or an improvement in economic efficiency caused by a project. NED benefits are categorized according to their effect on activity decisions as inundation reduction benefit, location benefit, or intensification benefit.

"Benefit standard." The willingness of users (benefiting activity) to pay for a proposed plan (user, activity).

"Benefiting activity." An activity which realizes an increase in net income because of a proposed plan (user, activity).

"Costs." The amount expended by an activity in order to generate output, normally excluding the rental value of the land. In this regulation, costs usually segregate those due to flood damages in order to facilitate analysis. However, flood damages are conceptually a cost of doing business. (NOTE: Project "costs" are a separate item).

"Damage susceptibility." The relationship between total value of a type of activity in a flood plain and the flood damages sustained by that activity. The relationship is a function of the characteristics of the flooding itself (depth, velocity, duration, etc.) and the objects flooded (dwelling, materials, etc.), and their location.

"Damages." Often used in text to mean flood damages (flood damages).

"Damages reduced." Often used in text to mean flood damages reduced (flood damages reduced).

"Depreciation." A loss from the upper limit of value. An effect caused by deterioration and/or obsolescence. Deterioration is reflected by wear and tear, decay or structural defects, obsolescence occurs in two forms: functional and economic.

"Development costs." The cost of preparing land for use by an activity (site development costs) plus, when applicable, cost necessary to make one site as valuable as another (associated costs). The difference in development costs is a component of changed net income.

"Economic benefit." Synonymous with benefit, for purpose of the economic development objective.

"Economic development objective." The objective of increasing the value of the Nation's output of goods and services and improving national economic efficiency.

"Economic efficiency." The objective of producing goods and services at the lowest possible cost per unit of output for a given level of output (economic development objective, economic rationality, economic benefit).

"Economic rationality." The assumption that activities having full knowledge of the flood hazard will attempt to maximize returns, and will not externalize their flood losses.

"Efficiency." Synonymous with economic efficiency for purposes of the economic development objective.

"Exceedence frequency (frequency of flooding)." The percentage of values that exceed a specified magnitude, and occur as the most extreme event within specified sequential time periods; the exceedence probability times one hundred. A 100 year exceedence interval corresponds to an exceedence frequency of 1.00.

"Exceedence interval (of flooding)." Also, sometimes the less desirable terms, recurrence interval and/or return period have been used. The average interval of time between values that exceed a specified magnitude; reciprocal of the exceedence frequency per 100 years. In an annual flood series, the average interval in which a flood of a given size is exceeded as an annual maximum. In a partial duration series, the average interval between floods exceeding a given size regardless of their relationship to any period of time. It should be noted that a flood corresponding to a 100 year average exceedence interval is not expected to be equaled only once during a 100 year period. A 100 year exceedence interval flood magnitude can be expected to be exceeded one or more times one out of four periods of 30 years length, one out of two periods of 70 years length, and about two out of three periods of 100 years length. The total period of time under consideration must exceed 1,000 to 10,000 years before the 100 year exceedence interval flood magnitude can be expected to be exceeded on an average of once for each 100 years.

"Existing benefits (and damages)." Average annual benefits (and damages) to activities affected by flooding at the time the study is completed.

"Exceedence probability (probability of flooding)." A probability that an event selected at random, the most extreme event within each sequential time period of a specified length, will exceed a specified magnitude. A 100 year exceedence interval corresponds to an exceedence probability of 0.01.

"Externality." Synonymous with external effect. An effect on parties other than users of the outputs of a plan; specifically, increased damages to activities outside the protected area under the with—as compared to the without—condition.

"Flood." Inundation arising from stream overflow, overland water flow, high lake stages, high tides and inadequate drainage plus stream related erosion, gullying, flood plain scouring, streambank cutting, shore or beach erosion and sedimentation.

"Flood characteristics." The physical properties of floods are an important variable in determining and projecting flood damages.

"Flood control project." (a) Broadly, a synonym for flood plain management plan; (b) Narrowly, a structural project by whomsoever undertaken.

"Flood damages." (a) Broadly, damages caused by a flood; (b) often "flood damages" mean "average annual damages." Floods vary in size and frequency. Average annual damages are yearly damages, on average, at any point in time, assuming one set of conditions and are independent of the interest rate used for project evaluation; (c) flood damages are a cost of doing business; reduction of the damage is therefore a reduction in costs which contributes to economic efficiency (synonymous with inundation damages).

"Flood damages prevented." Flood damages with a plan or project deducted from damages without the plan or project.

"Flood damages reduced." Synonym for flood damages prevented.

"Flood plain." Land physically inundated by a flood.

"Flood plain management plan." A plan for responding to the adverse effects of flooding (flood). This plan may envision structural measures, flood proofing, zoning, management, or a combination. This regulation provides for choosing plans on the basis of the economic development objective.

"Gross income." Total return to an activity. Usually expressed in dollars (synonym for gross or total revenues). Gross income, less costs, rent, and flood damages, equals net income for a given activity (revenues, costs, rent, flood damages, net income).

"Index." The relation or proportion of one amount to another; an indicator, e.g., density is an index of urbanization. The proper choice and use of an index is often critical to the accuracy of projections. Therefore, use of one item to indicate changes in another item should be based upon (1) establishing empirical relationship between the two items; (2) confirming a logical relationship between the two items, and (3) determining the likelihood that the relationships will continue over time and the nature of possible variances.

"Infrastructural locational advantage." See locational advantage.

"Intensification benefit." Benefit which arises because a plan or project induces an activity to modify its operation on the flood plain.

"Intensification of land use." An increase in the gross output of an existing activity at an existing site, due to a change in the factors of production.

"Inundation reduction benefit." The flood control benefit to those activities whose location decisions are unaffected by a proposed plan. It is the value of those flood losses prevented to those activities which would use the flood plain even without the proposed plan.

"Inundation damages." Synonym for flood damages.

"Land use." A description as to how land is utilized within the affected area. A change in land use is based upon affected area requirements and the ability of the flood plain to better meet these requirements given various levels of protection. A major source and starting point are land use maps, with support data, determined by responsible local, regional and Federal agencies. The detail number of levels of protection and number of years land use need be projected will vary with the plans being considered and the area being studied. The level of detail should be based upon the criteria of whether formulation and justification are affected.

"Location advantage." For any given demand for land, the desirability one parcel of land may possess over another; and advantage may be physical, aesthetic, infrastructural or a combination thereof. The former includes slope, foundation, potential for flooding, availability of water; infrastructural locational advantages are primarily psychological, such as nearness to existing population, accessibility to highways, civil stability, and proximity to market. Most physical advantages do not change significantly over time and are generally measured in terms of site development costs or in terms of hazard damage sustained. Infrastructural advantages will change over time as an area develops, depreciates or redevelops. It is most difficult to quantify infrastructural advantages. Measuring associated costs is one way, where it is possible to make two parcels of land equivalently valuable for an activity by a measurable expenditure (e.g., by putting in a road, by evaluating commuter costs between two sites, etc.). Where this is not possible, a direct estimate of the value of the location may be made. A starting point is to state the advantage(s) quantitatively; e.g., water supply available. A second step would be to attempt to measure the market value of comparable land and activities with and without the advantage. The purpose is to isolate unique advantages. Interviews with experts may also be helpful. Where the infrastructural advantage cannot be measured either directly or by associated development costs, the advantage should be listed qualitatively by the reporting planner.

"Location benefit." Changes in net income to those activities whose decisions as to where to locate are affected by the proposed plan.

"Market value." Synonym for value.

"Net income." For firms, the difference between the gross income and costs (or expenses). For households or public service activities, the difference between the value (market or simulated) of the good or service supplied and the alternative cost of providing that same service. The difference is net income for users and is the benefit attributable to a flood control project. It is emphasized that net income merely defines the benefit; it does not indicate how the benefit is to be measured. Costs exclude land rent except when specified otherwise in the regulation (costs, revenues, benefit).

"Period of analysis." The period of analysis is that time horizon over which needs shall be assessed and is the basis for the NED benefit-cost ratio. The period of analysis is 100 years for major

reservoirs, major long-term urban protection and main-line levees. It is 50 years for all other flood control measures.

"Physical locational advantage." See locational advantage.

"Productivity." (a) The ability to produce or increase output; (e.g.) normally expressed as a rate of output over time; (b) economic efficiency.

"Profit." Synonymous with net income, as used in this regulation.

"Project." See flood control project.

"Protection." A measure of the level of a flood protection or plan, generally measured by the exceedence frequency protected against (e.g., Standard project protection, 50-year protection). (exceedence frequency, threshold level)

"Rationality." See economic rationality.

"Rent." The value to, or the amount paid, a landowner for use of his raw land; a component of location benefit. Economic rent equals the net income of the occupying activity.

"Remaining flood damages." Flood damages which will occur even with a flood plain management plan (flood damages, flood damages prevented).

"Sensitivity analysis." The calculation of the rate of change of the objective function with respect to a particular parameter. An analysis of the components of a plan based upon alternative assumptions and/or projections to determine if a change in a measure would appreciably affect plan choice, design or schedule.

"Site operating costs." The costs of operating a given activity on a given parcel of land. The difference is a component of location advantage. (site development costs, associated costs, development costs, location benefit)

"Standard project flood." A large and improbable flood, usually simulated by placing the largest storm of record in a given region over a specific basin or sub-basin.

"Threshold level." For a given activity and year, the protection level at which the activity is indifferent to locating on or off the flood plain. The activity is indifferent when net incomes, on and off the flood plain, are equal. Threshold levels are crucial to location benefit measurement and to land use analysis.

"Uneconomic." An event which is not economically rational (economic rationality.)

"User." Synonym for benefiting activity.

"Value." In this regulation, value means market value; i.e., what a willing buyer will pay a willing seller for a good or service assuming full knowledge by both parties of the pertinent market characteristics of the good or service. The market may be simulated.

"Willingness to pay." The benefit standard for National Economic Development benefits attributable to a flood plain management plan.

"With project condition." The condition of having a specific flood control plan, regardless of sponsorship or operation.

"Without project condition." The condition of not having the specific flood control plan in operation. It is described in terms of what is most likely to occur within an area under evaluation without the specific action, regardless of sponsorship.

"Zoning." Authoritative restriction of uses to which land may be put. A form of land use regulation.

Subpart B—General Principles and Standards of Benefit Evaluation

§ 341.20 Definition and examples of national economic development objective.

This regulation applies where national economic development, providing for an increase in the value of the Nation's output of goods and services and improving national economic efficiency, is an objective. When this is the case, the development of water and related land resources results in increased production of goods and services which can be measured in terms of their value to the user. Increases in crop yields, expanding recreational use, and peaking capacity for power systems are examples of direct increases in national output which result from water and land resource developments. Such developments often result in an increase in the productivity of labor and capital used with these resources. Increases in earnings through changes in land use, reduced disruption of economic activity due to droughts, floods and inadequate water supplies, and removal of constraints on production through improved water quality are additional examples of direct increases in productivity from water and land development that further contribute to national output.

§ 341.21 Relationship of flood control programs to national economic development objective.

A variety of programs, such as flood plain management (including flood control and prevention), drainage, reduction of sedimentation, land stabilization and erosion control, contribute to the national economic development objective by improving the net productivity of flood prone land resources. This occurs either by a direct increase in total output or by reducing the costs for activities using land resources. In the latter case, the resources released are available for use elsewhere in the economy to further increase national economic output. These programs affect land resources and consequently the output of activities in the following manner:

(a) Prevention or reduction of inundation arising from stream overflow, overland waterflow, high lakes stages, high tides, and prevention of damage from inadequate drainage.

(b) Prevention or reduction of soil erosion, including sheet erosion, gullying, and flood plain scouring; streamback cutting, shore or beach erosion, and prevention of sedimentation.

(c) Removal or reduction of limitations on uses of specified land resources.

(d) Adjustments in the manner and mode of flood plain use in recognition of the flood hazard.

§ 341.22 General benefit standard for national economic development.

The benefit standard is the willingness of users (benefiting activities) to pay for each increment of output from a plan.

(a) *Willingness to pay* determines the values of the increase in output from a plan where total value is defined as the willingness of users to pay for each increment of output from a plan. The output of flood control plans is the increase in the productivity of land or the reduction in the cost of using land resources. When users are producers, willingness to pay is determined by the difference in net income accruing to users of land resources benefiting from the flood control plan compared with what the users would earn in the absence of such a plan. When users are consumers (as opposed to producers), willingness to pay is defined as the difference between the cost of obtaining a site of equivalent value in an alternative manner and the cost of using the protected flood plain. If the additional output from a plan is not expected to have a significant effect on the price of land of comparable quality to the protected site, these prices may be used in the estimation of plan benefits.

(b) *Users.* Users may be individuals, households, landowners, firms, or public entities.

(c) *Net income.* Net income is defined as the difference between the value (market or simulated) of output (goods or services) and the cost of (excluding land rent) of producing the output.

(d) *Non-national business and financial losses.* Losses to benefiting commercial activities which are compensated through increased business off flood plain are not national losses.

(e) *Externalities* are effects on parties other than users of the outputs of a plan. Flood damages may result from a plan beyond the area it is designed to protect. When plan induced damages occur to non-protected areas, they must be subtracted from the benefits to the protected area when calculating final benefits of a plan.

§ 341.23 Application of general benefit standards to flood control programs.

While there is only one benefit standard, there are three benefit categories thereunder reflecting different activity decisions made in response to the reduction of flood flows or hazards which result from a flood control plan; namely:

(a) *Inundation reduction benefit.* An activity uses the flood plain exactly the same with and without a plan. The benefit is the increase in net income to the flood plain activity. For activities not now on the flood plain, this benefit will occur only when it can be demonstrated that the activity will have a larger net income at the flood plain site than at the next most efficient available alternative site

(as defined in § 341.3 of this part) without the plan.

(b) *Intensification benefit.* A commercial, industrial or agricultural activity on the flood plain modifies its operation because the reduction in potential flood damages makes it profitable to do so. The benefit is the increased net income to the activity and landowner comparing the current and previous methods of operation. This benefit will occur when the increased output can be produced most efficiently under project conditions by intensified operation on the existing acreage as opposed to increasing production elsewhere or bringing new areas into production.

(c) *Location benefit.* An activity uses the flood plain with a plan but not without, as a result of the reduction in potential flood damages. The benefit is the difference in net income to the new activity comparing the flood plain site to the alternative off-flood plain site which would be used without the plan less the difference in net income for the activity displaced by the new activity.

Subpart C—Evaluation Procedure

§ 341.30 Prerequisites to evaluation procedure.

The following provides a description of those elements which are common to a consideration of all flood control in the plan formulation and evaluation process. Special consideration should be given these elements during the study, and they should be described in the final study report.

(a) *Description of flood plain management plans.* A flood plain management plan is a strategy contributing to appropriate use of flood plains principally by reducing potential flood damage. Such plans will normally involve a combination of measures, regardless of sponsorship, for modifying flood flows and/or reducing damage susceptibility. Each specific plan under consideration will be described in that portion of the report dealing with evaluation and measurement.

(b) *With and without analysis.* Each plan will be evaluated under strict adherence to the principle of with and without analysis. The with condition will be specific in terms of a plan, regardless of sponsorship or level of protection, rather than general terms, such as a flood control program. The without condition will be defined in terms of what is most likely to occur within an area under evaluation without a specific plan. The four cases that follow illustrate and clarify the appropriate without condition.

(1) *No alternative action in the absence of a Corps plan of action.* In this case, the appropriate without situation is that which will exist in the absence of any Corps action.

(2) *Alternative action already taken by other parties.* In this case some flood protection has already been provided. The appropriate without situation includes existing flood protection but without further action by the Corps or any other party.

(3) *Alternative action is anticipated to be taken before Corps action.* In this case, the appropriate without situation includes such anticipated protection but without further action by the Corps or other parties. For example, flood protection has not yet been provided but there are assurances that it will be provided before a Corps plan could be started.

(4) *Alternative action will be taken in the absence of a Corps plan, but if the Corps undertakes a plan no alternative action will be taken by other parties.* In this case, the appropriate without situation is that which will exist in the absence of action by any party, as in (b) (1) of this section. The rationale for this is that in formulating plans, evaluation of available alternatives (structural, non-structural and mixed) must be undertaken. Likewise a choice must be made from among these alternatives, including those which could be undertaken by other parties in the absence of a Corps project.

(c) *Application of Flood Disaster Protection Act to with and without conditions.* The adoption and enforcement of land use regulations pursuant to the Flood Disaster Protection Act of 1973 (Pub. L. 93–234) will be assumed, both with and without a Corps plan. This is to insure that Corps evaluation procedures conform to Federal policy.

(1) *Regulation certified or near certification.* The Corps office will assure itself that the land use regulation has been or will be certified by the Flood Insurance Administration (FIA) as adequate under 24 CFR 1910.3(c) and/or (d) and 24 CFR 1910.5. In such cases, the without conditions are developed pursuant to the regulation. Further structural, non-structural and mixed alternatives will be considered in Corps plan formulation. The with condition will assume a zoning ordinance compatible with the without condition ordinance in those cases where the 100 year flood is not contained by the Corps plan. Where the flood is contained, it may be assumed that no zoning ordinance will be in effect. This is consistent with FIA policy.

(2) *Regulation not yet certified.* It will be assumed that the local jurisdiction will adopt land use regulations certifiable to FIA in the near future under the without condition as a datum, and for the with condition when a residual hazard will remain. This applies to flood plains regulated pursuant to 24 CFR 1910.3 (a) and (b); to flood plains presently regulated by local ordinances independent of FIA; and to flood plains with no flood regulation presently in effect. The regulation assumed will include the following two crucial features: No further development of the flood plain unless the first floor of the building is elevated to the 100-year level for residences or flood proofed to that level for non-residences; and no occupancy of the floodway which when taken with other developments raises the height of the 100-year flood by greater than one foot anywhere in the flood plain. The possibility of a 24 CFR 1910.5 exemption will not be considered. In those cases where application of this sub-paragraph results in significantly higher benefits to the Corps plan than would be the case under an assumption of no land use regulations, the District will report this finding and the reasons therefore.

(3) *Exceptions.* In certain cases the prior provisions of this paragraph will not apply. These cases will involve situations where private, non-federally related financing of future development is likely. Such cases will be extremely rare and should be fully supported in the report by an adequate explanation of the unusual circumstances.

(4) *Other applications.* The impact of Pub. L. 93–234 on evaluation has not been fully determined. The use of reduction in premium rates as a benefit category is an example. For the time being, no further changes in evaluation procedure will be made.

(d) *Economic rationality.* The with and without conditions are defined as those which are most likely to occur under each condition. However, for purposes of evaluating structural components of a plan economic rationality will be assumed. (This assumption is necessary since it is contrary to Corps policy to encourage or perpetuate irrational flood plain use.) Economic rationality assumes that activities attempt to maximize returns, have full knowledge of the flood hazard, and will not externalize their flood losses. For those flood plains where a local zoning ordinance forms part of the with and without conditions, the basic test of economic rationality for occupancy is: Do the advantages of the flood plain exceed the cost of complying with the zoning ordinance plus remaining flood losses? For the few other flood plains, the basic test for occupancy is: Do the advantages of the flood plain exceed the expected flood damages or the cost of flood-proofing plus remaining flood losses, whichever is less?

(e) *Base Year Definition.* The base year is defined as the first year in which the recommended plan is expected to be operational. The choice of the base year should allow for the practical minimum time required for authorization, funding, construction and/or implementation, with no attempt made to account for unforeseen delays or unusual expediting in any procedural phase. The selection of the base year should be estimated on as realistic a basis as possible; the following is recommended as a guide:

Procedural phase	*Time allowance*
Submission of feasibility report to date of plan authorization.	2 years
Plan authorization to date of receipt of initial construction or implementation funds.	2 years
Receipt of initial funds to date plan becomes operational.	Variable depending upon scope and complexity of the plan; shall be identical to period during which interest during construction is charged under current directives.

(f) *Period of analysis.* The period of analysis is 100 years for major reservoirs, major long-term urban protection and main-line levees. It is 50 years for all other flood control measures. The period of analysis is the time horizon over which needs shall be assessed and is the basis for the NED benefit-cost ratio.

(g) *Amortization.* Benefits and costs for each flood plain management plan shall be brought to present worth as of the base year and amortized for 50 and 100 year periods. Projections beyond 50 years are difficult to support. Therefore, neither increases or decreases in flood control benefits for project years 50 to 100 will be assumed or accepted.

(h) *Benefit display.* Benefits shall be displayed in undiscounted average annual values for the current year, the base year, and by decade thereafter. Account will be taken of projected hydrologic, demographic, and economic changes. Average future hydrologic conditions shall not be used.

(i) *Price levels.* Benefits and costs shall be evaluated under prices existing at the time of submission of the report to OCE. In the case of agriculture, apply Water Resources Council (WRC) Guideline #2, *Agricultural Price Standards for Water and Related Land Resources Planning*, Feb. 1974, and subsequent revisions, for all projects covered by the Principles and Standards and related guidance.

§ 341.31 Evaluation procedure.

There are five major steps necessary to evaluate a flood plain management plan. These five steps are: Delineation of affected area; projection of anticipated activities within the affected area; estimation of land use demand; determination of flood plain characteristics; and projection of land use. The level of detail and presentation of each step will vary with the area being studied and should be based upon the criteria of whether plan formulation or evaluation are affected. For example, a stable economic setting, where existing damages justify or nearly justify the proposed plan, will normally require less detail in assessing future benefits than a plan justified primarily on future conditions.

(a) *Delineation of affected area.* The area affected by a proposed plan consists of the flood plain plus all other areas likely to serve as alternative sites for any activity which might use the flood plain if it were protected. A functional approach to delineating the affected area requires obtaining insight as to potential future uses of the flood plain. There are several methods of accomplishing this, such as simply observing current uses of the flood plain, holding public hearings, reviewing local plans, consulting influential citizens, community officials, private firms and utility companies, reviewing economic base studies, Standard Metropolitan Statistical Areas (SMSA) and other large area studies. Potential future uses should first be specified by broad categories including: Industrial (manufacturing), commercial, residential, open space, recreation, agriculture and other. Working circumferentially from the flood plain, alternative available areas for each such use must be specified. Sufficient area must be included to insure that the affected area is large enough to accommodate at least these major categories of potential future use. When the potential use of the flood plain includes industrial use within an SMSA, the entire SMSA is the affected area; for residential use, even within an SMSA, a much smaller area may be envisioned. In the case of agriculture, it is normally sufficient to specify alternative areas in more general terms.

(b) *Projection of anticipated activities within the affected area.* Projections of demographic and economic activity within the affected area are seldom influenced, in the aggregate, by a plan for flood control. A single set of projections should be developed, therefore, to serve as a basis for the entire analysis. Exceptions to the general rule will be supported by a special explanation of why a plan is likely to cause a different level of aggregate activity. Economic and demographic projections should be made for at least the following characteristics: Population, personal income, manufacturing employment and output, and agricultural output. For any given area, additional projections may be necessary depending upon the potential uses of the flood plain and the sensitivity of the plan to these projections. Projections should be made for the planning period (normally 50 years from the base year) at least by 10 year increments. Demographic projections should be based upon historical trends for the affected area, upon larger area trends or projections such as those put out by the Office of Business Economics, U.S. Department of Commerce and the Economic Research Service, U.S. Department of Agriculture (OBERS), and upon local master plans and projections. However, growth in the flood plain is not likely to be the same as for larger areas. The influence of applicable constraints such as quality of land available, environmental impact and local zoning ordinances must be made explicit in the analysis.

(c) *Estimation of land use demand.* Land use demand within the affected area is obtained by converting demographic projections (e.g., population) to acres. Such conversion factors will normally be derived from published secondary sources, from Corps studies of similar areas, or from empirical data available in the affected area. The categories of land use demand should be only as detailed as is necessary to reflect the incidence of the flood hazard and to establish the benefits derived from a plan. For example, if the affected area has considerable potential for high-rise apartments, then the population projection should be carefully converted to acres which include high-rise densities factors. Conversely, where residential use is small, detailed analysis of the residential sector is of lesser importance.

(d) *Determination of flood plain characteristics.* The existing characteristics of the flood plain must be delineated before it is possible to determine its potential uses. Therefore, an inventory of the flood plain will be undertaken in order to determine those characteristics which make it attractive or unattractive for the land use demands established in paragraph c of this section. Emphasis will be placed upon those characteristics which which distinguish the flood plain from other portions of the affected area. The following categorization should be used as a guide.

(1) *Inherent characteristics of a flood plain.* All or most flood plains have the following characteristics: Flooding; floodway, natural storage; open space, recreation, wildlife, wetlands; transportation; and other.

(i) *Flooding.* A description of the flood situation will be presented, including a designation of high hazard areas. This description will include the characteristics of the flooding such as depths, velocity, duration, debris content, area flooded by flood of selected frequencies, including 100 year frequency, historical floods and Standard Project Flood (SPF). See also § 341.41(c)(1) of this part.

(ii) *Floodway, natural storage.* A description and delineation of those areas which, if urbanized or structurally protected, would affect natural storage, velocity or stage, or in any way affect flood flows elsewhere will be presented.

(iii) *Open space, recreation, wildlife, wetlands.* Many flood plains are potential recreation, open space, wetland, or wildlife preserves, particularly those proximate to an urban area. The potential of the flood plain for these purposes must be recognized and presented.

(iv) *Transportation.* Flood plains near navigable streams have inherent attractiveness for industries which demand water-oriented transportation. Flood plains also often serve as sites for railroads, highways, pipelines, and related facilities which are not susceptible to serious flood damage yet tend to attract industry to the area.

(v) *Other attributes.* Other inherent attributes include: Soil fertility, reliability of water supply, waste disposal, sand, mineral and gravel deposits.

(2) *Physical characteristics.* The existence of certain physical characteristics may effectively preclude use by some activities likely to compete for flood plain land. For example, it may not be feasible for certain types of heavy manufacturing activity to locate in areas possessing unfavorable soil foundation characteristics. Therefore pertinent physical characteristics should be described, including slope, soil types, water table, among others.

(3) *Available services.* Most activities require some or all of the following services: Transportation facilities (highways and rail), power, sewerage, water, availability of labor force, and the like. The availability of such services in or near the flood plain will be indicated, including comparisons with other portions of the affected area. Future planned services for the affected area will also be presented.

(4) *Existing activities.* The inventory of the flood plain will include a list of existing activities, the number of acres and density of each. The total acreage of the flood plain should thus be accounted for; vacant or unused acreage should be separately categorized.

(e) *Projection of land use.* Given the existing characteristics of the flood plain and the remainder of the affected area previously designated, land use demand must be allocated to flood plain and non-flood plain lands, with and without each specific flood plain management plan.

(1) *Basic factors.* The allocation shall be based upon a comparison of three sets of factors. These are: (i) The flood plain characteristics; (ii) the characteristics sought by potential occupants; and (iii) the availability of sought-after characteristics in the non-flood plain portions of the affected area.

(2) *Criteria.* The principle of economic rationality shall be applied. The flood plain will not be used unless it possesses characteristics which give it a significant economic advantage over all other available sites within the affected area. If such advantages exist, the analyst must determine whether they overcome potential flood losses. Flood losses include those to the benefiting activity and to those additional activities induced to use the flood plain; e.g., residential use, induced neighborhood commercial and public facilities. Flood losses will be specific to the zone of the flood plain being considered. A zone is delineated by frequency of flooding, (See § 341.13, "Exceedence Frequency" of this part), under "without plan" conditions, from which the incidence of all benefits shall be specified. This should include flood magnitudes with exceedence intervals of 25, 50, 100 years, the standard project flood and the design flood.

(3) *Procedure.* A consistent procedure will be applied to every plan and protection level under consideration, and to the without plan condition. The appropriate procedure is:

(i) Determine whether future benefits are likely to affect the design, formulation or justification of a flood plain management strategy. If so, proceed to next step.

(ii) Eliminate all uses for which the flood plain offers no advantages and all activities which cannot tolerate flooding or flooding of a certain type (e.g., high velocity).

(iii) For uses attracted to the flood plain, a list of advantages in comparison to alternative sites in the affected area will be presented. For each advantage, the analyst will indicate the importance of the advantage in location choice (e.g., essential, important, desirable, or of marginal advantage). Special attention should be paid to minimum characteristic requirements of each activity type (e.g., ground surface slope may not exceed 15 percent for "X" activity type). Where applicable, the advantage will be explicitly quantified.

(iv) For advantaged uses, an estimate of potential flood losses should be presented. Often economic losses are minimal; e.g., green belts, municipal parks, game refuge or the use of simple open space. In such cases, continued flood plain use may be assumed. Often a high level of protection will reduce potential losses for any activity in all areas of the flood plain to negligible amounts. In such cases, those activities for which there is a maximum absolute advantage will use the flood plain.

(v) The advantages of the flood plain to related flood hazard will be compared in order to determine whether, for low levels of protection or under the without condition, the advantages exceed the potential flood losses. Historical experience in the flood plain or in nearby or similar flood plains; the ratio of losses to approximate net returns or capital investment; guidelines by Federal and private lending authorities; local master plans which explicitly take flood hazards into account; WRC guidelines; residential interviews; and business interviews are all methods by which such a determination can be made short of detailed quantification.

§ 341.32 Irrational use.

While allocation of land use will proceed under the assumption of economic rationality, there will be instances where occupancy of flood plains in the general area exists, but is not apparently rational; e.g., single family residential use in frequently flooded areas. This should be confirmed in several ways. One is by direct interview of occupants; e.g., did the occupant know he was in a flood plain? What degree of hazard did he anticipate? Another is by discussion with local authorities. A third is by observing historical occupancy and sequence of development to determine whether high hazard flood plain occupancy is common. If deliberate high hazard occupancy is observed, the location decision may be assumed to be rational. Once the existence of irrational use is verified, and the probable increased future irrational use confirmed, the report should (a) base future benefits to structural protection only on rational use, (b) if possible, assist the local entity in devising sound regulatory ordinances to prevent continued irrational use, and (c) claim the prevention of irrational use as a benefit to such regulation, flood plain information, land purchase and other similar non-structural plans or plan components.

§ 341.33 Presentation.

For the recommended plan and for the without condition, there should be presented a map or other graphic display clearly indicating existing and projected land use for the affected area, with appropriate exceedence intervals as indicated in § 341.31(e)(2) of this part.

Subpart D—Benefit Measurement

§ 341.40 Characteristics of flood plain management benefits.

The use of a flood plain is likely to change even in the absence of a flood plain management plan. This change may result in an increase or decrease of economic activity. A benefit accrues by reducing or modifying the flood hazard to such economic activity. This benefit is referred to as an "inundation reduction benefit." In addition, activities which would use the flood plain even without a project may be encouraged to intensify their use because of a plan (e.g., where a shift from lower to higher value crops occurs). This is referred to as an "intensification benefit." Finally, a plan may induce new economic activity into the flood plain (e.g., where a shift from agricultural to industrial use occurs). This benefit is referred to as a "location benefit".

§ 341.41 Flood damages without project.

The determination of the level of existing and future flood damages without a plan leads directly to computation of the inundation reduction benefit.

(a) *Types of flood damage.* Flood damages can be classified as physical damages or losses, emergency costs, and business or financial losses. Each activity affected by a flood experiences losses in one or more of these classes. Such classification assists in identifying and evaluating the losses and in relating variations in their magnitude to the range of flood conditions expected with and without the project.

(1) *Physical damages* include the damages to or loss of buildings or parts thereof; loss of contents, including furnishing, equipment, decorations, stock of raw materials, materials in process and completed products; cost of cleanup; loss of roads, sewers, bridges, power lines, and so forth.

(2) *Business and financial losses* include the various economic losses other than direct physical damages and emergency costs resulting from a flood, such as net loss of normal profits and return to capital, labor and management in the readily identifiable zone of flood influence. Such losses bear no consistent relation to physical damages and must be derived from specific independent economic data for the interests and properties affected. To the extent that such losses cannot be compensated by postponement of an activity or through transfer of the activity to business establishments not affected, prevention of such loss results in a contribution to national economic development.

(3) *Emergency costs* will include those additional expenses resulting from a flood that would not otherwise be incurred, such as evacuation and reoccupation, flood fighting, disaster relief, increased expense of normal operations during the flood, increased costs of police, fire or military patrol, and abnormal depreciation. Emergency costs should be determined by specific survey or research and may not be estimated by applying arbitrary percentages to the physical damage estimates.

(b) *Existing flood damages without project.* Existing flood damages are potential average annual damages to activities affected by flooding at the time

the study is completed. Existing damages are those either expressed for a given magnitude of flooding or as computed in the damage frequency process. No projection is involved. The basis for the determination of existing damages shall be losses actually sustained in historical floods. Therefore, the analyst should specify the year and month for all significant discharges above zero point of damage and indicate damages actually sustained by reach or zone and type of property and activity. Data on historical flood losses must be supplemented by appraisals and an inventory of the capital investment (including structures and contents) within the flood plain. Estimates of damages under existing conditions for floods of magnitude which have not historically occurred must be computed. Average annual losses will be estimated by using standard damage-frequency integration techniques.

(c) *Future flood damages without project.* These are damages to economic activities which are expected to use the flood plain in the future in the absence of a plan. Future includes any time period after the year in which the study is submitted to OCE. In order to ultimately relate costs to benefits, however, future damages must be discounted to the base year.

(1) *Hydrologic changes.* Changes in basin land use may result in major alteration of the drainage characteristics, particularly surface run-off; such hydrologic changes must be projected for the planning period. Average future hydrologic conditions shall not be used; such techniques obscure situations where a project level of protection may be totally unacceptable by the end of the planning period.

(2) *Economic changes.* Economic changes can be expected to result in a change in the level of flood losses in the future. The following three paragraphs discuss the projection of future flood damages. The level of detail in projecting future flood losses should be based on the effect of the analysis on plan formulation and evaluation. A benefit-cost ratio for existing condition will always be shown. If it is greater than unity, the projection of future benefits may be accomplished in abbreviated form, unless it would distort the comparison of alternatives or the cost allocation and cost sharing in multiple purpose projects. In the latter situation the detail and accuracy of the estimates of flood control benefits should be comparable to benefit estimates for other purposes (e.g., water supply).

§ 341.42 Measurement and projection of physical flood losses.

Measurement and projection of flood damages must be based upon the establishment of actual, observed relationships between damages, flood characteristics, and those indicators used for measurement and projection. Thus, projections of flood damages should be made on the basis of the actual regression coefficients as modified by consideration of constraints which change the historically derived relationship between flood damages and a given independent variable. Basically, damages are a function of the number and value of each physical unit of property in the flood plain adjusted for the damage susceptibility at each stage of flooding. All of these interrelationships must not only be made explicit in the analysis, but their accuracy and representativeness supported by empirical evidence. There are three steps to be used in measuring flood damages for a future year: Estimating the number and size of physical units; estimating the future value of units; and determining damage susceptibility of units.

(a) *Physical units.* The first step in measuring flood damages for a future year, is to determine from the land use analyses the number and size of physical units in the flood plain by hazard zones for each of the following categories:

(1) *Residential.* The number of physical units can be obtained by relating the number of acres to density, persons per dwelling unit and similar ratios. These ratios can be expected to change over time; however, major shifts would be improbable. Several ratios should be tried to test for consistency, accuracy and sensitivity of any one estimate. Extreme care must be taken to subdivide the residential category into single family and mutliple dwelling units since damage per unit of value vary widely for each. Multiple dwelling units should be further subdivided; e.g., into high rises, garden apartments, and low density multiple. Single family residences should be classified as conventional or mobile home units. Type of construction is also important, as discussed below under damage susceptibility.

(2) *Commercial.* The number of commercial establishments can be estimated by relating sales to population, output to sales, acres to output, square footage to gross sales, or by a similar technique. Again, extreme care must be taken to subdivide commercial categories; e.g., retail, wholesale, warehouse, professional and administrative, highway commercial, and other appropriate subcategories affecting the value and damage susceptibility of the physical unit. A causal relationship must be demonstrated between the activity projected (e.g., warehouse), and the independent variable (e.g., manufacturing output within affected area). The interdependence between commercial activity and related socio-economic indicators should be closely checked for consistency and dependability.

(3) *Industrial.* The number of industrial establishments is estimated less readily than commercial or residential. This is because broad regional or national needs will usually dictate the demand for most industrial products. It is not reasonable to assume that the aggregate industrial output of an affected area will be influenced by a flood control program. However, the location of these activities within the area could easily be affected. Direct interviewing of existing industries and consultation with a responsible land use planning entity as to possible shifts in industrial location patterns is usually feasible due to the relatively small number of industries likely to occupy a given flood plain. Indices of physical units which may be appropriate include capital to output ratios, output per employee, sales to output ratio, capital investment per unit of output, value added per gross sales, and rolling stock per ton-mile. Land available for industry as indicated by local zoning and land use plans may act as a constraint upon development but does not determine the amount of industry which will locate in the flood plain. Recognized projections such as OBERS, McGraw-Hill, National Planning Association, the Federal Reserve, and Resources in America's Future, among others, should also be utilized.

(4) *Public facilities.* These cover a wide range of different types of physical units; e.g., roads and bridges, schools, government offices, sewage treatment facilities, water treatment plants, and parks. Many of these can be projected in the future by determining physical requirements as a function of the population and industrial mix of the affected area. It is noted that some types of public facilities, such as streets and schools will increase virtually in direct proportion to population. Other types, such as junior colleges, will appear for the first time only when a high regional population density is reached. Other types of public facilities do not vary with the population of the local area but rather with regional or national demands; e.g., major freeways, state office buildings, and major universities. As with the industrial category, maximum use should be made of accepted published projections, direct interviews and established land use plans.

(5) *Agriculture.* Acres of land under production, types of crops, and changes in yields per acre are the principal physical units of agricultural measurement. As a rule physical structures on agricultural lands are limited to farmhouses, barns, and related buildings. The number is generally a function of farm type and size. Estimates of physical equipment, such as irrigation equipment, and tractors, in the flood plain may be based upon regional characteristics and trends in farm capital/output ratios or farm capital/land ratios as well as model farm data. Capital equipment for agricultural production is often mobile and can be removed from the hazard of most floods. Farm residence and personal property can also be advantageously located outside of the flood plain in many instances. Information specifying the types of agricultural damages is to be displayed. Additional information should be included to provide details on the time of year and the stage of the growing cycle in order that the origin of the flood damages associated with each of the historical floods can be explained.

(b) *Value per physical unit.* (Not available at this time.)

(c) *Damage susceptibility.* Once the number of physical units and the value associated with each unit are known, damage susceptibility relationships must be established as a function of total value of each physical unit and the flood characteristics of the stream, such as velocity, depth, duration, volume, debris control and salinity. Some of the determinates of damage susceptibility are:

(1) *Location within the flood plain.* An industry located between the 50 and 100 exceedence interval of a flood plain is less flood prone than the same one located within the fifteen year flood plain.

(2) *Type of activity.* Certain types of activity are more susceptible to damages than others. For example, single family residences usually sustain greater damage per unit value than high-rises. Another example is in comparison of damage to crops and single family residences. The latter are usually built to allow for rapid lot drainage; hence, major damage often does not begin unless depth of flooding exceeds one or two feet above natural ground level. Flood duration similarly affects alternative activities in different ways. The calculation of remaining damages should be particularly cognizant of activity type. Plans should consider the implications of elevation, flood proofing, evacuation and relocation, and all other management options.

(3) *Vertical development.* As the value of each physical unit increases, historical trends indicate that the number of stories in buildings increases because of land scarcity. For most streams, flood waters do not reach second stories or above. In some areas basements are traditional and in other areas slab foundations predominate; both affect damage susceptibility.

(4) *Material used.* Some materials are inherently less prone to flood damage than others. For instance, cinder block is normally less prone to flood damage than wood.

(5) *Individual response.* As property value increases, owners may be expected to take individual actions to reduce damage susceptibility, such as keeping valuable household items on the second story. The cost of flood proofing serves as a limit on the level of damages which a rational activity is willing to accept. The rational action of an average individual should apply when trying to anticipate the response to a flood hazard situation.

(6) *Unknown commodities and materials.* Increases in damages will not be assumed where the nature of commodities and materials projected in the future are unknown. This is because the susceptibility of such commodities and materials to flood damages cannot be known, and many aspects of "known" projected activity cannot be accurately perceived.

§ 341.43 Projection of business and financial losses.

Business losses can be projected to increase in the future only under special circumstances. The special circumstances are when it can be shown that future losses cannot be compensated through a transfer of sales to other establishments. Such a showing will require a determination of the number and location of similar businesses in the general area. In no event will increases in physical losses be used to directly project business losses.

§ 341.44 Projection of emergency costs.

Emergency costs encompass a wide variety of programs. Some, such as emergency shelter and food, are primarily a function of the occupancy of the flood plain, but not of the value of development in the flood plain itself. In no event will emergency costs be projected to increase as a direct function of physical losses.

§ 341.45 Innundation reduction benefit.

The inundation reduction benefit is the value of reducing flood losses to activities which would use the flood plain without any plan. Structural measures directly reduce flood flows. Evacuation reduces flood losses without modifying flood flows. Early warning systems reduce flood losses. Flood plain regulations governing flood proofing and building materials also reduce damage susceptibility.

(a) *Flood damages reduced.* Inundation reduction benefits are measured as the reduction in the amount of flood damages or related costs. Related costs are those which would be voluntarily undertaken by economically rational individual activities to reduce flood damages. An important example is where flood proofing is expected without a plan. In such cases the benefit is the cost of flood proofing plus damages assuming flood proofing, less residual damages.

(b) *Market value of land.* The difference in the market value of land with and without a project reflects the capitalized increase in net income associated with the project. This proxy is not perfect and in some instances, such as flood plain evacuation, is meaningless. Therefore, the reduction in flood damages often provides a more practical and representative measure of inundation benefits than does increase in land value. However, the land value approach is a useful check on benefits, especially in a stable agricultural situation. The influence of externalities must be carefully considered whenever land values are used in the benefit algorithm.

§ 341.46 Location benefit.

The location benefit is the value of making flood plain land available for new uses by reducing flood hazards to activities which would use the flood plain only with protection. An example is when a plan permits industrial use of a flood plain which would be in agricultural use or vacant without the plan. Any flood plain management strategy which reduces potential flood losses can potentially give rise to a location benefit. Location benefits are narrowly defined in this regulation. The benefit for producers is the difference in the net income accruing to users of land resources which would locate on the protected flood plain when compared to what these users would earn in the absence of a plan. For consumers, the benefit standard is defined as the difference between the cost of obtaining a site of equivalent value in an alternative manner and the cost of locating on the protected flood plain. Three techniques are available to measure location benefits. These are: Net income differences, threshold levels, and changes in the market value of land. These techniques represent a compromise between theory and the time and data limitations facing Districts. Because they are not equivalent, two methods will be used in each calculation of location benefits. The choice of values for location benefits used in the final benefit calculation should be based on an explicit evaluation of the reliability of the alternative estimates. Finally, the reduction of flood related expenses is an upper bound on location benefit, no matter which method is used.

(a) *Net income differences.* The benefit is derived in six steps:

(1) For a displacing activity, calculate the net income difference for the activity (where costs exclude land rent and flood damages) between the alternative site and the flood plain site.

(2) For a displaced activity (if any), calculate the net income difference (where costs exclude land rent and flood damages) between the alternative site and the flood plain site. This step is primarily designed to insure that the loss of agricultural productivity on a fertile flood plain is not overlooked.

(3) Add the increases in net income of the displacing activities less the decreases in net income of the displaced activities.

(4) As with all evaluation categories, residual damages to induced development must be substracted from gross location benefits. Note that induced development includes activities which locate on the protected flood plain solely because another activity locates there. For example, if residential development occurs on the flood plain, schools, commercial businesses and other activities will locate there also. This reduces the benefit attributable to the flood control plan because residual damages to such activities must be deducted from location benefits.

(5) Flood damages reduced to activities which have been displaced by the induced activities should be subtracted if such reductions have already been counted as part of an inundation benefit.

(6) External flood damages must be deducted. Taken together, steps 4, 5 and 6 call for a thorough analysis of induced and remaining flood damages.

The net income approach will have greatest practical application where the advantages of the flood plain relative to alternative sites are specifically identifiable and quantifiable, and the displaced activity is agricultural (or vacant).

(b) *Threshold levels.* The threshold level is that level of protection at which a new activity is economically indifferent between location on the flood plain and off the flood plain. Viewed from a flood frequency perspective, for example, an

activity may be indifferent to moving onto the flood plain if a 50-year level of protection were assured. Any level of protection above 50 years, therefore, would induce the activity onto the protected flood plain. The benefit above this level may be quantified in terms of flood damages reduced to the new activities. Flood damages reduced to the old activity must be subtracted to avoid double counting of benefits if they have been claimed as inundation benefits. Finally, external flood damages must be deducted (similar to paragraph (a)(6) of this section.

(1) *Rationale.* The method is analogous to the use of flood damages reduced to measure the inundation benefit. It will be noted that in the case of inundation benefits, the threshold level of protection is no protection.

(2) *Some suggested methods of measurement.* The following are suggested as aids in quantifying threshold levels:

(i) *Direct interview with potential flood plain users.* Because of the limited number of interviews necessary, this approach would be particularly useful in intensification situations and for industrial, commercial, and home construction firms which are already in the general area.

(ii) *Institutional sources.* Various sources on information include: local flood control districts, local zoning ordinances and Federal flood plain management offices.

(iii) *Flood damages per acre.* Where the flood plain is fairly homogenous except for the flood hazard, the flood damages per acre (or other unit) on the portion of the flood plain which is expected to experience the same development pattern with or without the plan approximate an acceptable level of flood hazard. Every advantage should be taken of statistical sampling techniques under these conditions.

(iv) *Similar projects.* The effect of Federal or local projects along the same stream or other similar streams may indicate the threshold level. For example, if 50-year channel works induced residential development in a nearby area, the 50-year protection threshold level for the study area would probably be similar.

(v) *Location within the flood plain.* Low levels of protection may induce development of only those areas of the flood plain which are not subject to large damages.

(vi) *Prior determinations.* Where a detailed analysis (subsequent paragraphs) of development and operating costs has established a given threshold level for a stream, the same level may apply for other streams in the area or other streams with similar characteristics.

(vii) *Shape of damage curve.* For example, where potential damages occur primarily in larger floods, a high level of protection will be necessary to induce activities to locate in the flood plain.

(c) *Changes in the market value of land.* Changes in market value of land can be used to measure location benefits. The value of land is established through market transactions and is influenced by buyers and sellers considering the estimated effects of risk, uncertainty, probability of higher use, and the time lapse before particular land parcels are expected to shift into a higher order of use. Consequently, market land value represents the present capitalized value of the anticipated future income stream (rents) associated with the expected uses of the land. Changes in the market value of land can be used to measure the benefits to activities which would locate in the flood plain when there are important externalities associated with a plan. Thus, there are two uses of changes in the market value of land.

(1) *Location benefit to users.* The benefit is the difference in the market value of flood plain land with and without a plan.

(i) *With plan value.* If the plan does not result in a major addition to the supply of land in the area, the value with protection is the market value of comparable flood free land. If the plan results in a major addition to the supply, the effect on the general price of land should be taken into account in estimating the value of flood plain lands with protection. The flood free land must be comparable in terms of physical and infrastructural characteristics, e.g., water availability, transportation, soil stability, utilities, amenities, and so forth.

(ii) *Without plan value.* The value of nearby flood plain sites should be used or, where reasonable, the current value of the flood plain. In either case, the current and, where available, past market values of the flood plain will be reported. Actual market values will be used, not capitalized income values. Hence, it must not be assumed that the value of land being used for agriculture in an urban or urbanizing situation is the capitalized value of agricultural returns and that any value higher than that is due to (*a*) speculation on a Corps' project or (*b*) lack of knowledge. On the contrary, without values in excess of agricultural values are to be expected, reflecting the probability of future use as well as existing and anticipated infrastructural investments (e.g., highways, water supply, etc.). In addition, the comparable without project sites should not be flood free agricultural sites.

(iii) *Projection of market value of land.* Projected increases in the market value of land with and without a plan may not be used to measure flood control benefits. This is because the current market value of land theoretically captures the expected stream of benefits over time.

(iv) *Data problems, sources and display.* Comparable sites should always be specified both as to location and as to sales data utilized for establishing the price. In addition, the comparable sites should be displayed on a map. The number of observations and an analysis of the range of values must be based on sound statistical procedures. In addition, the difference in with and without values must be net of differences due to zoning and to parcel size. Market values may be obtained from reports of land transactions, appraisals and assessments and other sources depending upon data availability and reliability.

(v) *Computation of benefits from market value data.* The Federal rate of return will be used in converting market values to average annual benefits. This is because of the difficulties in converting a nominal private rate of return to a real rate of return by adjusting for inflation. Of course, residual damages to induced activities must be deducted. Increased flood damages to areas outside the protected area must also be deducted and inundation benefits to displaced activities must be deducted if these were claimed as inundation benefits.

(2) *Effects from externalities.* In addition to its effects on flood damages outside the protected area, a plan may have other effects on activities near the flood plain. For example, when a plan permits the development of a flood plain which otherwise would be open or green space, nearby activities may suffer losses. These losses would be reflected in a decline in land values in the nearby areas. Conversely, open or green space as a component of a flood plain management plan may raise surrounding land values. When such externalities are expected to be important and can be estimated, they should be included in the location benefit calculation.

§ 341.47 Intensification benefit.

The intensification benefit is the value of a plan to activities which are thus enabled to utilize their land more intensively. An example is where the reduction of the risk of flooding permits a user to invest additional labor or capital in the land, thereby producing higher crop yields or converting woodland or pasture to crops. This same type of benefit can accrue in urban settings. For example, homeowners may decline to renovate older homes due to a flood threat or properly utilize land available for expansion; the removal of the threat results in an intensification benefit. A flood plain management plan which embodies preservation or enhancement of open space, parks or historic sites may also result in large intensification benefits in urban settings where a high demand for such uses exists. Residual flood losses to these intensified activities must also be considered when calculating net flood damages.

(a) *Direct measurement.* Revenues and costs are usually available for agricultural activities. Direct measurement of net income changes is therefore possible. Net agricultural income for future years may be obtained by estimating anticipated net productivity gains in agriculture for the area under analysis. Factors of production should be made explicit. The analyst should utilize expert opinion, past trends and data from "model" farms such as those run by agricultural experiment stations. Net productivity is the increased yields and commodity price per acre adjusted for the change in costs, including inundation

damages associated with the new operation. Under the majority of circumstances, it may be assumed that no individual project is likely to influence the productive practices of agricultural activity elsewhere. Although extremely difficult to measure, the cumulative effect of agricultural intensification benefits for each project should reflect the net reduction in agricultural income lost elsewhere because of the project. This means that the benefit is limited to the savings in cost for induced production when compared to production on upland areas, and must be so calculated whenever possible. In no case may this exceed the savings in the cost for induced production in the flood plain itself.

(b) *Threshold levels.* Similar to the measurement approach for location benefits, intensification benefit can be measured by those flood damages reduced above the threshold level.

(c) *Market value of land.* As discussed under inundation reduction and location benefits, market value is normally not preferred as a measure of benefits; although it does provide a useful check upon other techniques and may serve as a parameter of benefit worth.

§ 341.48 Remaining flood damage situation: Categorization.

The remaining damages are those which are expected to occur even with a flood plain management plan in operation. Categories of remaining damages are:

(a) Damages to activities which would occupy the flood plain with as well as without the plan. Damages to these activities may be increased by the presence of induced activities because the induced activities reduce the natural storage area of the flood plain (e.g., by floodway encroachment). Such effects are a part of the remaining damages.

(b) Damages to activities which would occupy the flood plain only with the plan. Again effects of increased flood heights resulting from induced development are a part of the remaining damages.

(c) Increased damages to activities outside the protected area under the with—as compared to the without—condition. For example, the plan itself or the development induced by a plan may cause increased or new flooding on the fringe of the flood plain or up and downstream. Such external effects are a part of the remaining damages.

§ 341.49 Remaining flood damage situation: Display.

The quantity and nature of remaining flooding, particularly for large and infrequent floods, will have an important bearing on plan formulation, evacuation and recommendation as already indicated §§ 341.44–341.46 of this Part. Benefits resulting from a plan must be net of residual damages. Therefore, the benefit evaluation and measurement part of any report shall separately describe and quantify remaining flooding. In order that an unacceptably large remaining loss condition does not remain under any given plan, and in order that plan induced losses are not overlooked, it is most important that remaining losses are carefully and explicitly presented. The remaining flood situation should be described by at least the following parameters:

(a) *Average annual equivalent residual flood losses.* Such losses are to be presented in average annual equivalent flood losses, existing and projected, brought to present worth, and amortized.

(b) *Residual average annual losses for selected years.* Annual losses, on an undeferred basis, shall be presented for the current year, the base year, and by decade thereafter. Full account will be taken of projected hydrologic demographic and economic changes. Average future hydrologic conditions shall not be used.

(c) *Standard project flood.* Flood losses with project are an extremely important factor in plan choice in urban situations, especially where the possibility of a catastrophic flood remains. A catastrophe occurs when an urban area is crippled for a sustained period, where a substantial infusion of Federal, state or regional rehabilitation funds (disaster relief) is necessary, or where it could be expected to be deemed a Federal or state disaster area. Likewise, a catastrophe occurs when a serious danger to life exists or extensive property damage results. It is possible that a plan may be effective in reducing average annual flood losses but ineffective against large (SPF) floods; e.g., thus levees may be overtopped and far upstream reservoirs may not effectively reduce damaging stages at the downstream damage center. A plan could actually increase the disaster potential of an area by inducing unwise use of the flood plain unless land use is regulated with full recognition of the remaining hazard. Therefore, remaining flooding in a SPF flood, with the plan, must be fully described. With plan, SPF damages will be presented on an undeferred basis for the selected years listed in the prior subparagraph. The number of structures and acres by land use type, the disruption of essential services (water, power, fire protection and sanitary services) and the distance to unaffected essential services, the depth of flooding, and anticipated warning time, the velocity, duration, typical debris content and any other pertinent descriptors of the residual flood situation will be presented. Similarly, damages and descriptors under without plan conditions will be presented for comparative purposes. The presentations of SPF losses will clearly distinguish between losses to plan induced or intensified development, losses to development which would locate in the flood plain with and without the plan, and increased losses to development off the flood plain.

Subpart E—Validation of Benefit Evaluation

§ 341.50 Methods for adding validity to benefit evaluation.

The following is a brief discussion of several methods by which the planner can improve the credibility of the results of a proposed plan. The suggested techniques are not all-inclusive, and many may not be applicable in the majority of analyses. The inclusion of such tests may be required under certain conditions and will be expected whenever there is any significant question regarding the validity of the underlying analysis.

(a) *Sensitivity analysis.* Sensitivity analysis is a necessary feature of any good, multivariable analysis. The planner cannot be satisfied with the definition of a plan for resource (e.g., land, water, recreation, etc.) allocation that is optimal for a specific set of conditions if the plan is particularly sensitive to changes in the model. Water and land resource allocation models require the planner to predict both the rate of changes in the assumed values of the model parameters and the range of conditions over which any particular plan is recommendable; these data are obtained by sensitivity analysis. In cases where a solution is found to be particularly sensitive to a given variable or parameter, such information must be made explicit in the plan formulation and evaluation report.

(b) *Utilization of sampling techniques and statistical testing.* This method can be applied whenever practical, statistically sound sampling techniques can be utilized in the collection of data on flood plains and their affected areas. Sampling is not only an excellent means of reducing the cost of the study effort, but can often result in data which are statistically superior to a total survey approach in terms of accuracy and consistency. In addition, the planner is in a position to predetermine a sample size which will produce results of a comparable accuracy (and cost) with the remaining study elements. This is possible by choosing a sample size whose level of confidence (probability) is no greater nor less than that of the study as a whole. Except when a true sample is utilized, statistical measures of probability cannot be accurately quantified. Likewise, knowledge of data characteristics such as distribution and mean variation can assist the planner substantially in the design of sensitivity tests, optimal solutions and overall estimates of study result probability for further plan formulation and evaluation.

(c) *Quantifying variable relationships.* Whenever a cause and effect relationship is assumed to exist between a study (dependent) variable and one or more independent variables, a coefficient of correlation and determination must be cited prior to its introduction into plan formulation and evaluation. Whenever this same relationship is projected into the future, the source of the projected, independent variable must be cited and the final regression coefficients conspicuously displayed in the final report. In addition, an indication of how well the regression equation described the assumed relationship must also be stated; e.g., a measure of the dispersion of the actual values of Y about the regression line,

similar to the variance or the standard deviation for the mean average of the previously discussed sample. There are numerous standard analytical computer routines which the planner can utilize for this task, including those available within the Corps System of Information Retrieval and Analysis for Planners (SIRAP) program.

§ 341.51 Assumptions and hypotheses.

A summary of study assumptions and hypotheses to be utilized in a study effort should precede the presentation of the analysis. An indication of the sensitivity of study results (direct or indirect) to changes in each study assumption, hypothesis or variable should be noted at the time of its introduction into the analytical process; (e.g., a hypothetical example might read, "the study assumed a fertility rate of 2.7 percent by the year 2000. Alternative assumptions of 3.1 percent and 2.45 percent were also tested and resulted in less than 5 percent change in aggregate water supply requirements and a 3 percent change in total benefits, with no change in project design implied."). It should be noted that many assumptions possess a certain consistency. These interdependencies should be tested as a unit, for if one is accepted the others are presumed; (e.g., the production of fertilizer for domestic use presumes a given level of crop production).

§ 341.52 Probabilities of occurrence.

Although often difficult to quantify, some indication of probability should be associated with each variable, hypothesis and assumption found to be significant to the study results. Whereas study results may be highly sensitive to a given assumption, if the planner has a high level of confidence (high probability) in its occurrence, its use in plan formulation and evaluation would be justified. If high sensitivity is combined with a low level of confidence, the planner should attempt to avoid its use in the analysis or at least conspicuously display a range of values or options associated with alternative levels of probability from which he chose. In extreme cases where the probability of occurrence or validity may be critical (analytically or politically), the methods by which these probabilities were derived should be well documented. This would include, when applicable, a routine use of the null hypothesis, specific tests of significance (t-test, standard deviation, variation) measures of skewness, tests of variability of data values within an array (Chi-square and regression), and various approaches to hypothesis testing and estimation.

§ 341.53 Some specific checks.

In addition to the recommended plan's Benefit-Cost ratio, which must be cited, there are several specific checks which should also be included in a flood control report:

(a) *Break-even years.* There are two significant break even years. As used herein, annual charges for multiple-purpose projects are based on allocated costs:

(1) The project year in which undiscounted annual benefits first exceed annual charges.

(2) The project year in which discounted benefits exceed annual charges assuming no further increases in benefits.

(b) *Internal rate of return.* The rate of interest at which benefits equal costs over the period of analysis (i.e., benefit-cost ratio equals 1.0).

(c) *Discount rate.* For authorized projects, the effect of using the current Federal discount rate should be presented.

(d) *Value per structure.* As previously discussed, increases in future damages relate to increases in the number of structures as well as increases in the value of structures and contents. Whenever increases in damages are based upon increases in value, a sensitivity analysis should be accomplished under the alternate assumption; i.e., there is no increase in the average value of structure or contents; that increases in damages are due solely to increases in the number of structures and/or shifts from one type of structure to another.

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